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INTEGRATION OF ALTERNATIVE TREATMENTS FOR CONTROL OF POSTHARVEST INSECT PESTS OF WALNUTS

J. A. Johnson, E. L Soderstrom, C. E. Curtis, and P. V. Vail

Average annual production of dried fruits and nuts in California was 1,057,797 tons for 1985-1990, with an annual value of over $1.2 billion, increasing to $2.4 billion after processing. Postharvest insects cause product loss, conservatively estimated at $96 million each year, through direct damage, contamination with fecal material, webbing and insect parts, and by favoring increased mold growth and product degradation. Currently, postharvest insect control for dried fruits and nuts is dependent on the use of methyl bromide and phosphine fumigants. Various toxicological, environmental, and regulatory concerns and the development of resistance in target pest populations make the future availability of fumigants uncertain. Although several non-chemical methods have been demonstrated to provide either immediate control or sustained protection, no single method provides an economical alternative to fumigation throughout the postharvest system. Our current project seeks to integrate short-term disinfestation methods with long-term protective techniques to overcome the limitations of individual non-chemical methods for dried fruits and nuts. In particular, alternative control methods for postharvest walnuts have been difficult to develop because of the relative sensitivity of this product; changes in walnut storage conditions often result in high levels of rancidity. This report summarizes results from a test using a controlled atmosphere of 0.4% O_2 for 6 days as an initial disinfestation treatment, followed by various long-term protective treatments.

Materials and Methods: Sixteen commercial raisin bins (4 x 4 x 2 ft) each filled with 500 lbs of Hartley walnuts were used in the test. For the initial disinfestation treatment, eight bins were treated at a time. We produced a treatment atmosphere of 0.4% O_2 with a hollow fiber membrane gas separation system (PrismAlpha Nitrogen System CPB-5) in a 10 x 10 x 8 ft treatment room. The walnuts were treated for 6 days after an average purge time of 43 hours. Test insects were 25-day-old navel orangeworm (*Amyelois transitella*) placed individually into drilled walnuts. Earlier work showed that navel orangeworm at this stage (fifth instar larvae and young pupae) were the most tolerant to the treatment. For each initial treatment, 300 nuts were infested; 200 were placed on the product surface in the treatment room, and 100 were kept untreated as controls. All nuts were removed after treatment and held for adult emergence.

After the initial treatment, bins were moved into long-term treatment rooms. Four bins were moved to a 10 x 10 x 8 ft holding room and held without further treatment (control). Walnuts in four more bins were treated with an Indianmeal moth granulosis virus preparation at a rate of 0.0534 g/lb nuts, and placed in a similar holding room (GV). Four bins were placed in a 20 x 8 x 8 ft refrigerated cargo container which maintained a storage temperature of 8-11°C (46-52°F) (low temperature). The remaining four bins were left in the initial treatment room, where an atmosphere of 5.0% O_2 was maintained (CA). Five mated pairs of Indianmeal moth (*Plodia interpunctella*) were introduced into each of the four treatment rooms each week for 11 weeks. Wing traps baited with Indianmeal moth pheromone (Consep Biolure®) were placed into each room. The traps were monitored each week in the control, GV and low temperature rooms. The trap in the CA room was examined at the end of the test.

Just before each long-term treatment, a 15 lb walnut sample was removed from the surface of each bin. From these, 100 nuts were opened and evaluated for damage. Additional subsamples were sent to the Dried Fruit Association of California and SunDiamond Walnut quality control laboratory for standard quality evaluation. Similar samples were taken and evaluated 4, 8 and 12 weeks later from the control, GV and low temperature rooms; the CA room was sampled when the test ended at 13 weeks.

Results: No navel orangeworm adults emerged from walnuts exposed to the initial 0.4% O_2 controlled atmosphere treatment. Adult emergence from untreated walnuts was about 80%. The results of the long term protective treatments are summarized in Table 1. No damage due to Indianmeal moth was found in any of the samples taken at the beginning of the test (0 weeks). During the course of the test, the only live Indianmeal moth larva recovered from any of the treated samples was found in the GV treatment at the 4 week sample. One Indianmeal moth damaged nut was recovered in the 12 week sample from the low temperature treatment, but no larvae were found and the damage was determined to have occurred prior to treatment. In contrast, high numbers of Indianmeal moth larvae were recovered from the untreated control in the 12 week sample; almost 75% of the nuts were found infested with one or more Indianmeal moth. Pheromone trap results are shown in Figure 1. High numbers of moths were caught in the control room six weeks after the beginning of the long-term test. Moth density rose to more than 550 moths/week by the end of the test. Low numbers of moths (≤12/week) were caught in the GV treatment room. No Indianmeal moths were caught in either the low temperature or the CA treatment rooms. Product quality results have not been returned from the Dried Fruit Association, or from SunDiamond Walnut, but no discernible quality problems were detected in treated walnuts when samples were taken.

The results of our initial tests are encouraging; the initial CA treatment proved effective in disinfesting walnuts of navel orangeworm, and all three long term protective treatments kept Indianmeal moth populations at acceptable levels. Each of the protective treatments have both advantages and disadvantages. The GV treatment was the least costly and would require little plant modification, but was specific for the Indianmeal moth and, although detectable damage was prevented, did not completely prevent Indianmeal moth development. The CA treatment was very effective, and was more energy efficient than the low temperature treatment, but treatment rooms could not be entered without first purging the atmosphere. The low temperature treatment was energy expensive, but treatment rooms could be entered at will. All three treatments maintained product quality throughout the test.

Additional walnut tests are underway, and similar tests with raisins are being planned. Ancillary studies involving the effect of controlled atmosphere and low temperature on Indianmeal moth reproduction, persistence of the granulosis virus in storage, and location of Indianmeal moth in product profiles are also being conducted.

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Table 1. Damage in nut samples taken from each treatment room (N=400).

		Number of Nuts Damaged (%)											
Time (weeks)	Treatment	IMM		NOW		Other insects		Total insects		Other damage		Total damage	
0	Control	0	(0.0)	12	(3.0)	9	(2.3)	21	(5.3)	33	(8.3)	54	(13.5)
	CA	0	(0.0)	9	(2.3)	20	(5.0)	29	(7.3)	26	(6.5)	55	(13.8)
	GV	0	(0.0)	11	(2.8)	35	(8.8)	46	(11.5)	19	(4.8)	65	(16.3)
	Low Temp	0	(0.0)	6	(1.5)	16	(4.0)	22	(5.5)	38	(9.5)	60	(15.0)
4	Control	2	(0.5)	18	(4.5)	20	(5.0)	40	(10.0)	33	(8.3)	73	(18.3)
	GV	1	(0.3)	6	(1.5)	47	(11.8)	54	(13.5)	36	(9.0)	90	(22.5)
	Low Temp	0	(0.0)	15	(3.8)	2	(0.5)	17	(4.3)	23	(5.8)	40	(10.0)
8	Control	71	(17.8)	13	(3.3)	9	(2.3)	93	(23.3)	20	(5.0)	113	(28.3)
	GV	0	(0.0)	5	(1.3)	26	(6.5)	31	(7.8)	64	(16.0)	95	(23.8)
	Low Temp	0	(0.0)	16	(4.0)	2	(0.5)	18	(4.5)	43	10.8	61	(15.3)
12	Control	292	(73.0)	14	(3.5)	6	(1.5)	312	(78.0)	16	(4.0)	328	(82.0)
	CA	0	(0.0)	6	(1.5)	10	(2.5)	17	(4.3)	13	(3.3)	30	(7.5)
	GV	0	(0.0)	6	(1.5)	30	(7.5)	36	(9.0)	58	(14.5)	94	(23.5)
	Low Temp	1	(0.3)	8	(2.0)	5	(1.3)	14	(3.5)	30	(7.5)	44	(11.0)

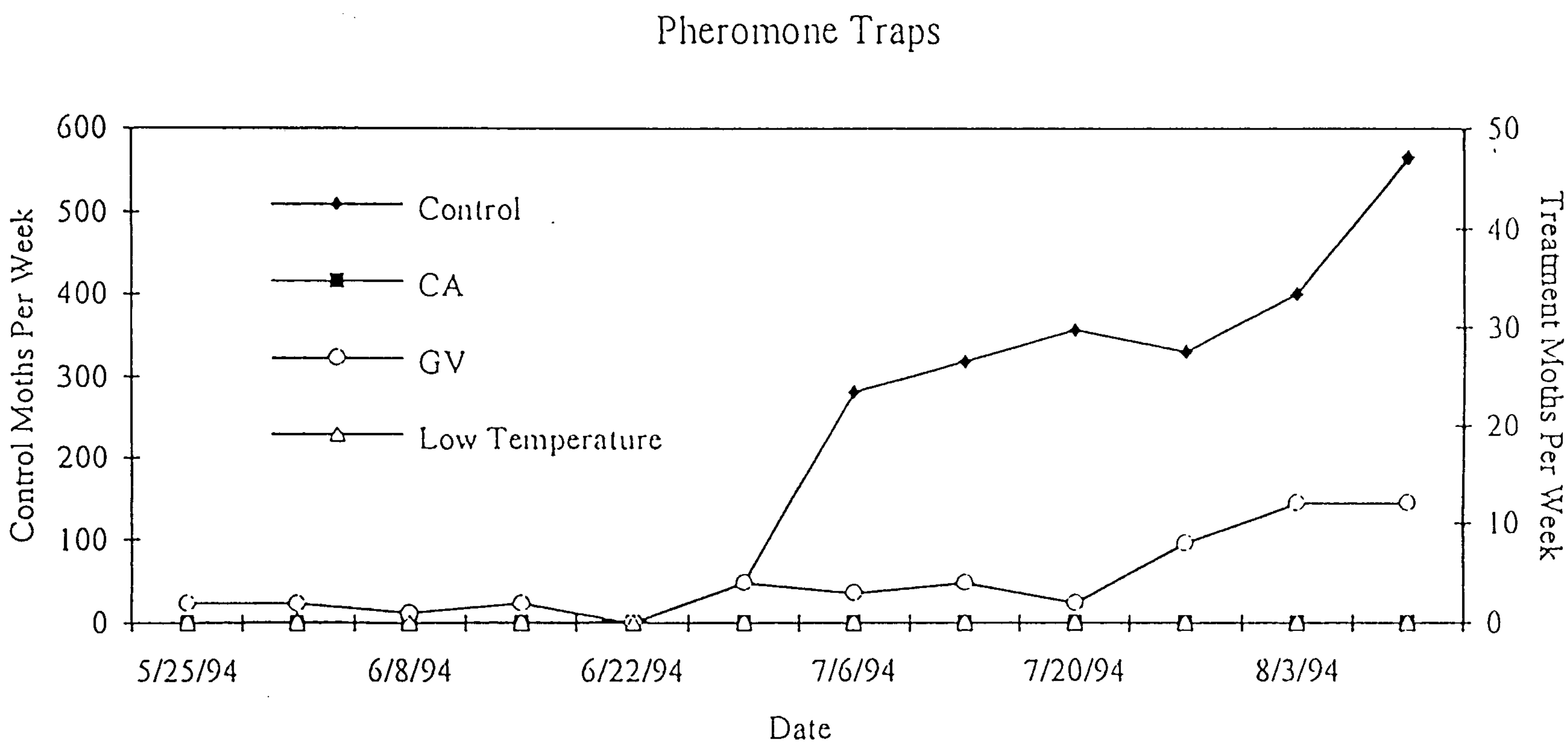

Figure 1. Number of Indianmeal moths recovered each week in pheromone traps placed in treatment rooms.